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(54) Vehicle air bag system

(57) A vehicle air bag system is provided with an air bag that inflates and unfolds to cover the entire front surface of a front pillar (3). When it is judged based on the detection operation of a collision detection device (10) that there is a risk of colliding with a pedestrian, a hood pop-up device (11) is actuated and the rear end part of the hood (1) moves up, widening the gap between the rear end part and the front windshield (2). Simultaneously, the air bag module (15) is actuated and the air bag (18) expands out from the gap. The air bag inflates and unfolds so as to cover the entire front surface of the front pillar (3) from the base to the upper end thereof.

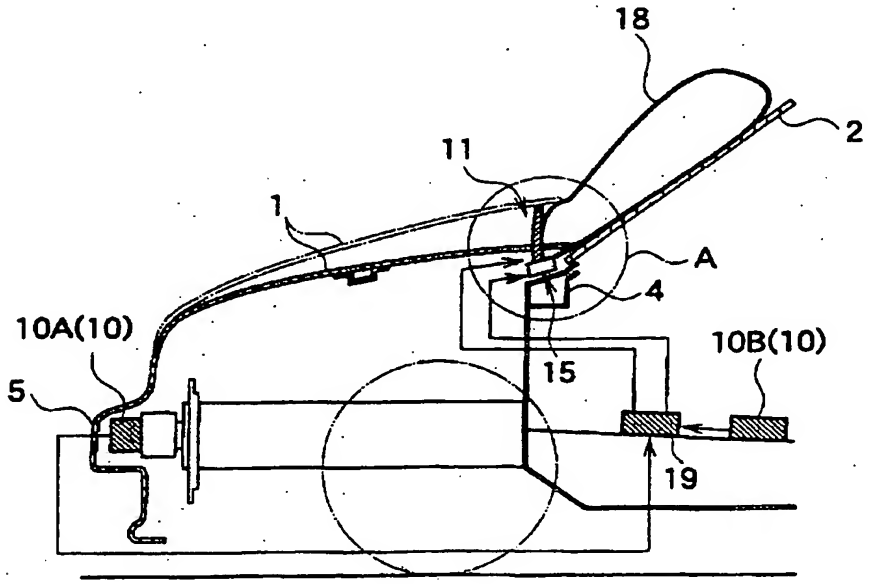

Fig. 2

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Description

[0001] The present invention relates a vehicle air bag system. More specifically, the present invention relates to a vehicle air bag system that covers the front pillars of the vehicle body.

[0002] The air bag system proposed in Laid-Open Japanese Patent Publication No. 5-281671 has an air bag module stored inside the front pillar such that the air bag inflates over the front surface of the front pillar. The air bag system proposed in Laid-Open Japanese Patent Publication No. 2000-79859 has an air bag located in the gap between the rear end edge of the engine hood and the front windshield such that the air bag inflates along the entire the rear end edge of the engine hood in the transverse direction.

[0003] In view of the above, there exists a need for an air bag system which is an improvement over the above-mentioned prior art. This invention addresses this need in the prior art as well as other needs, which will become apparent to those skilled in the art from this disclosure.

[0004] It has been determined, from the disclosure, that the former invention, in which the air bag module is stored inside the front pillar, has the following drawbacks: the air bag module installability is poor because the closed cross sectional area of the front pillar is limited, the structure becomes complex, and the front pillar becomes larger making visibility poor.

[0005] It has been determined,from the disclosure, that the latter invention is structured so that the air bag inflates and unfolds along the entire rear end edge of the engine hood in the transverse direction. Consequently, the air bag module is large and its installability is poor. Furthermore, such a structure is disadvantageous in terms of cost and the air bag cannot cover the entire front surface of the front pillar from the base part to the upper end part.

[0006] The present invention provides a vehicle air bag system that can inflate and unfold the air bag so as to cover the entire region reaching from the base part to the upper end part of the front side of the front pillar without harming the installability of the air bag module.

[0007] In accordance with one aspect of the present invention, a vehicle air bag system is provided with a collision detection device, a hood pop-up device and an air bag module. The collision detection device produces a detection signal upon detection of a collision between a front of a vehicle and an obstacle. The hood pop-up device is arranged under a rear end part of a hood to move up the rear end part of the hood when actuated based on the detection signal from the collision detection device. The air bag module that is arranged in a cowl top under the rear end part of the hood. The air bag module has an air bag that is inflated to expand out toward a front windshield from between the cowl top and the rear end part of the hood when the hood pop-up device is actuated. The air bag is configured to cover a region ranging from a base part to an upper end part of a front surface of a front pillar.

[0008] These and other objects, features, aspects and advantages of the present invention will become apparent to those skilled in the art from the following detailed description, which, taken in conjunction with the annexed drawings, discloses a preferred embodiment of the present invention.

[0009] Referring now to the attached drawings which form a part of this original disclosure:

Figure 1 is a perspective view of the overall appearance of an automobile that uses the present invention;

Figure 2 is a partial cross sectional view showing the front portion of the automobile shown in Figure 1;

Figure 3 is a partial cross sectional view that corresponds to region A in Figure 2 and shows the first embodiment of the present invention;

Figure 4 illustrates the air bag folding procedure for the first embodiment of the present invention;

Figure 5 is a perspective view of the up condition of the rear end edge of the engine hood in the first embodiment of the present invention;

Figure 6 is a perspective view showing the appearance of the inflated and unfolded condition of the air bags in the first embodiment of the present invention;

Figure 7 is a partial plan view illustrating the unfolded condition of the air bags shown in Figure 6;

Figure 8 is an enlarged perspective view of region B in Figure 6;

Figure 9 shows partial cross sections that were taken along line C-C in Figure 7 and serve to explain how the first embodiment of the present invention functions to prevent the air bag from shifting sideways;

Figure 10 shows partial cross sections that illustrate the inflation and unfolding of the air bag of the first embodiment of the present invention in stages;

Figure 11 is a partial plan view illustrating the sideways shifting prevention guide device of the second embodiment of the present invention;

Figure 12 is a perspective view showing the appearance the sideways shifting prevention guide device of the third embodiment of the present invention;

Figure 13 is a partial perspective view of the key components in region D of Figure 12;

Figure 14 is a partial plan view illustrating the sideways shifting prevention guide device of the third embodiment of the present invention;

Figure 15 shows partial cross sections that illustrate the inflation and unfolding of the air bag of the fourth embodiment of the present invention in stages;

Figure 16 is a partial cross sectional view illustrating the fifth embodiment of the present invention; and

Figure 17 is a flow chart illustrating an example of the control operations of the air bag system of the

present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] Selected embodiments of the present invention will now be explained with reference to the drawings. It will be apparent to those skilled in the art from this disclosure that the following description of the embodiments of the present invention is provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

[0011] Referring initially to Figure 1, an overall perspective view of an automobile or vehicle V is illustrated equipped with an air bag system in accordance with a first embodiment of the present invention. Figure 2 is a partial cross sectional view showing the front portion of the vehicle V shown in Figure 1. In both Figures 1 and 2, the vehicle V has an engine hood 1, a front windshield 2, a pair of front pillars 3 and a cowl top 4. The front pillars 3 extend vertically on both sides of the front windshield 2, while the cowl top 4 extends in a transverse direction at the bottom part of the front windshield 2. The bases of the front pillars 3 are typically joined to the side ends of the cowl top 4.

[0012] As used herein, the following directional terms "forward, rearward, above, downward, vertical, horizontal, below and transverse" as well as any other similar directional terms refer to those directions of a vehicle equipped with the present invention. Accordingly, these terms, as utilized to describe the present invention should be interpreted relative to a vehicle equipped with the present invention.

[0013] The air bag system of the present invention basically includes a collision detection device 10, a pair of hood pop-up devices 11 and a pair of air bag modules 15. The air bag system of the present invention serves to reduce an impact for pedestrians by covering the front pillars 3.

[0014] The hood pop-up devices 11 are arranged under both sides of the rear end part of the engine hood 1 to move up the rear end part of the engine hood 1. The hood pop-up devices 11 are actuated based on a detection signal from the collision detection device 10 that detects a collision between the front of the vehicle V and an obstacle.

[0015] The air bag modules 15 are arranged under both sides the rear end part of the engine hood 1. More specifically, the air bag modules 15 are preferably arranged on the cowl top 4 at positions that are slightly offset towards the center of the vehicle V from the positions where the hood pop-up devices 11 are arranged.

[0016] Each air bag module 15 is arranged inside a module case 16 as shown in Figure 3. Each air bag module 15 is equipped with an inflator 17 and an air bag 18. The inflator 17 is ignited and generates an inert gas when the hood pop-up device 11 is actuated based on the detection operation of the collision detection device 10. The air bag 18 is folded and stored inside the module case 16. The air bag 18 is inflated due to the gas generated by the inflator 17 so as unfold the air bag 18 to cover the entire region reaching from the base part to the upper end part of the front side of the front pillar 3.

[0017] As shown in Figure 4, the air bag 18 is equipped with a substantially rectangular the central part 18a and upper and lower sleeve parts 18b and 18c. The central part 18a of the air bag 18 inflates and unfolds long and at a slant from the module case 16 toward the front pillar 3. The upper and lower sleeve parts 18b and 18c that have the following characteristics: (1) they are provided on the central part 18a in a continuous manner; (2) each has a substantially triangular shape with its base side forming one of the lateral sides of substantially the upper half of the central part 18a located therebetween; and (3) they form a substantially rectangular shape that extends in the vertical direction when they inflate. Thus, when the air bag 18 inflates and unfolds, it covers the front surface of the front pillar 3 from the base part to the upper end part thereof as previously explained.

[0018] The air bag 18 is stored in the module case 16 as follows. First, the upper and lower sleeve parts 18b and 18c are folded on top of the substantially upper half of the central part 18a from the aforementioned base sides as indicated by the arrows in Figure 4 (A). Then, as indicated by the arrows in Figure 4 (B), the central part 18a is rolled or folded up from its upper end so that the upper end is rolled or folded on top of the upper surface of the inner end of the central part 18a.

[0019] The hood pop-up device 11 is affixed to the cowl top 4 or some other frame member in the engine compartment such as the hood ridge upper reinforcement (not shown) that is joined to both sides of the cowl top 4 and extends toward the front of the vehicle V. The hood pop-up devices 11 are located at positions that are further towards the outside of the vehicle V in the transverse direction than the air bag modules 15.

[0020] Preferably, the hood pop-up device 11 is a device that electromagnetically raises the stay 12 by a prescribed lift amount instantaneously so that the rear end part of the engine hood 1 is moved up. In this embodiment, as shown in Figure 5, a bracket 13 is coupled at one end with a pin to the upper end of the stay 12. The other end of the bracket 13 is fastened to the rear end part of the engine hood 1. The stay 12 and bracket 13 form a hood hinge.

[0021] The air bag modules 15 are installed at positions that are slightly offset towards the center of the vehicle V from the installation position of hood pop-up device 11, as previously explained. The lower sleeve part 18c contacts the stay 12 when the air bag 18 inflates and unfolds after the rear end part of the engine hood 1 has moved up. Therefore, in this embodiment, the stay 12 is used effectively as a stopper 20, which prevents the air bag 18 from shifting sideways in the transverse

direction of the vehicle V as described later.

[0022] In order for the stopper 20 to prevent the sideways shifting of the air bag 18 even more effectively, the lower sleeve part 18c is sized to wrap around stopper 20 when it inflates and unfolds, as shown in Figures 7 and 8.

[0023] A deformation prevention member 21 that prevents the rear end part of the engine hood 1 from deforming due to the inflation and unfolding of the air bag 18 is provided on the rear end part of the engine hood 1 in at least the region where the air bag 18 inflates and unfolds. Also provided is an upper guide 22 that prevents the air bag 18 from arching up when the air bag 18 expands out from the gap between the rear end part of the engine hood 1 and the front windshield 2.

[0024] The perimeter of the engine hood 1 is formed so that the perimeter of the outer hood panel 1a is joined with the perimeter of the inner hood panel 1b by hemming or seaming. In this embodiment, as shown in Figure 3, the required region of the rear end part of the hood 1 is hemmed such that the rear end edge of the outer hood panel 1a is expanded downward in a curved shape. This results in a so-called the circular folded edging part 21a that increases rigidity of the hood 1, and thus, serves as the aforementioned the deformation prevention member 21.

[0025] The inner hood panel 1b has a downwardly facing protruding part 22a that is formed so as to expand in a curved shape on the inner hood panel 1b at positions above the air modules 15 and in front of the circular folded edging part 21a. The aforementioned guide 22 for preventing the air bag from arching up comprises the circular folded edging part 21a, the protruding part 22a, and the recessed part 22b formed between the circular folded edging part 21a and the protruding part 22a.

[0026] The gap between the rear end part of the engine hood 1 and the front windshield 2 is set so that, under normal conditions, it is large enough to store a wiper device (not shown). Therefore, the circular folded edging part 21a and the protruding part 22a protrude by an amount that does not hinder the storage of the wiper device.

[0027] Additionally, a lateral guide 23 that prevents the air bag 18 from shifting sideways toward the outside in the transverse direction of the vehicle V when the air bag 18 expands is provided on the lower side of the rear end part of the engine hood 1. In this embodiment, the lateral guide 23 prevents sideways shifting is formed as shown in Figure 9, by forming a circular folded edging part 23a located in a region corresponding to the installation section of the air bag module 15 on the rear end lateral edge of the outer hood panel 1a. In addition to the circular folded edging part 23a, a downwardly protruding part 23b is also formed on the lateral part of the rear end of the inner hood panel 1b such that the lateral guide 23 comprises the circular folded edging part 23a and the protruding part 23b. The lateral guide 23 acts as sideways shifting prevention guide means.

[0028] In this embodiment, the collision detection device 10 comprises a distance sensor 10A and a G sensor 10B. The distance sensor 10A is arranged as shown in Figure 2 on the lower side of the front bumper 5 and electrically detects a collision between the front of the vehicle V and an obstacle. The G sensor 10B is used with conventional air bags that reduces an impact to passengers in a frontal collision, and thus, detects the deceleration in the longitudinal direction of the vehicle V and generates an electric signal.

[0029] The distance sensor 10A electrically detects the distance between the automobile and a pedestrian in front of the automobile. This distance is outputted to the controller 19 as a trigger signal that actuates the hood pop-up device 11 and the air bag module 15. The controller 19 executes a prescribed computation based on the trigger signal and the detection signal from the G sensor 10B. As discussed later, when it is determined that there is the risk of a collision with the pedestrian, the controller 19 sends a prescribed actuation signal (actuation current) to the hood pop-up device 11 and the air bag module 15.

[0030] Next, the control operations of the air bag system of this first embodiment will be discussed using the flowchart shown in Figure 17.

[0031] In step S1, when a pedestrian approaches the front of the vehicle V, the distance sensor 10A which is arranged in the front bumper 5 of the front end of the vehicle V as previously described, measures the relative distance S between the vehicle V and the pedestrian.

[0032] When a pedestrian approaches the front of the automobile, the driver normally applies the vehicle brakes rapidly so as to avoid a collision with the pedestrian. In step S2, the G sensor 10B detects the generated deceleration G of the vehicle V resulting from this rapid braking.

[0033] In step S3, the controller 19 executes a prescribed computation based on relative distance S measured by the distance sensor 10A and the value of the deceleration G measured by the G sensor 10B and determines whether or not there is a risk of collision with the pedestrian.

[0034] When it is judged that a collision risk exists (YES) in step S3, the control moves to step S4. The actuation current is sent to the electromagnetic actuator of the hood pop-up devices 11, the stays 12 are lifted instantaneously, and the rear end part of the engine hood 1 is moved up by a prescribed lift amount.

[0035] The amount of time that elapses from when the actuation current is supplied to the hood pop-up devices 11 until the rear end part of the engine hood 1 moves up by a prescribed lift amount is preset in the controller 19. After the prescribed amount of time has elapsed, the control moves to step S5 and actuation current is sent to the air bag modules 15. The inflators 17 are ignited and generate gas. The pressure of this gas causes the air bags 18 to expand out toward the front windshield 2 from the gap between the rear end part of the engine

hood 1 and the front windshield 2. The air bags 18 inflate and unfold in such a manner that they cover the entire regions from the base parts to the upper end parts of the front surfaces of the front pillars 3.

[0036] Thus, the rear end part of the engine hood 1 is moved up by the hood pop-up devices 11 and the gap between the rear end part of the engine hood 1 and the front windshield 2 is widened. The air bag modules 15 are actuated and the air bags 18 expand almost simultaneously with the widening of this gap. Therefore, the air bags 18 expand smoothly out from the gap toward the front windshield 2. The air bags 18 inflate and unfold so as to cover the entire front surface of the front pillar 3 as described previously.

[0037] As a result, the air bags 18 prevent direct contact between the pedestrian and the front pillars 3 and the air bags 18 makes it possible to soften the impact dependably.

[0038] In the initial stage of the inflation of the air bags 18, the moving up of the rear end part of the engine hood 1 creates a gap between the rear end lateral part of the engine hood 1 and the front fender 6. There is a tendency for the air bag 18 to shift sideways to the outside in the transverse direction of the vehicle V and pass through this gap. This sideways shifting of the air bags 18 is deterred by the guide 23 (the sideways shifting prevention guide device) provided on the lower side of the rear end part of the engine hood 1 and proper inflation and unfolding toward the front pillars 3 can be accomplished.

[0039] In this embodiment, the guide 23 comprises the circular folded edging part 23a formed on the rear end lateral edge of the outer hood panel 1a and/or the protruding part 23b formed on the lateral part of the rear end part of the inner hood panel 1b. As a result, the guide does not require separate specialized members and is advantageous in terms of cost. Also, when the guide 23 is formed from the circular folded edging part 23a and the protruding part 23b, the sideways shifting of the air bags 18 can be deterred at multiple stages during the inflation of the air bags 18 as shown in Figure 9 (A) to (C), and thus, the sideways-shifting prevention effect can be increased.

[0040] Also, the air bags 18 touch the rear end part of the engine hood 1 in the initial stage of inflation and unfolding when the air bags 18 expand out toward the front windshield 2 from the gap between the rear end part of the engine hood 1 and the front windshield 2. However, since the deformation prevention member 21 is provided on the rear end part of the engine hood 1, deformation of the rear end part of the engine hood 1 by the internal pressure of the air bags 18 is prevented and the air bags 18 can be made to unfold properly without hampering the unfolding performance and unfolding direction of the air bags 18.

[0041] More particularly, in this embodiment, the deformation prevention member 21 does not require special reinforcing members and is advantageous from the standpoints of both design and cost because it comprises the circular folded edging part 21a formed on the rear end edge of the outer hood panel 1a. Furthermore, since the circular folded edging part 21a protrudes downward in a curved shape, the circular folded edging part 21a can deter unstable behavior in which the air bags 18 wrap upward around the rear end edges of the engine hood 1 in the initial stage of the inflation of the air bags 18.

[0042] Additionally, the upper guide 22, which prevents the air bags 18 from arching up, is provided on the lower side of the rear end part of the engine hood 1. Consequently, in the initial stage of the inflation of the air bags 18, the upper guide 22 deters unstable behavior in which the air bags 18 arch up and separate from the front pillars 3 and the air bags 18 can be made to inflate and unfold properly along the front surfaces of the front pillars 3.

[0043] More specifically, the upper guide 22 serves as an arch-up prevention guide device that comprises the circular folded edging part 21a, the curved protruding part 22a provided on the inner hood panel 1b, and the recessed part 22b formed between the circular folded edging part 21a and curved protruding part 22a. Consequently, as the air bags 18 inflate, the upper surfaces of the base fabric align with the undulated shape of the upper guide 22 as shown in Figure 10 (A) to (D) and the upper surfaces of the base fabric takes on an undulated shape. The flow of gas along the upper surfaces of the insides of the air bags 18 is directed downward at one point (as indicated by the arrows in the same figure) due to the undulated shape and the mainstream of the gas flow is made to flow substantially in alignment with the slant of the front windshield 2 and the front pillar 3. As a result, the arch-up behavior of the air bags 18 can be effectively deterred.

[0044] The air bags 18 are equipped with a substantially rectangular the central part 18a that inflates and unfolds long and at a slant from the module cases 16 toward the front pillars 3 and upper and lower sleeve parts 18b and 18c that have the following characteristics: (1) they are provided on the central part 18a in a continuous manner; (2) each has a substantially triangular shape with its base side forming one of the lateral sides of substantially the upper half of the central part 18a therebetween; and (3) they form a substantially rectangular shape that extends in the vertical direction and cover the front surface of the front pillar 3 from the base to the upper end thereof when they inflate. Thus, when the air bags 18 inflate, substantially rectangular the central parts 18a unfold long and at a slant from the module cases 16 toward the front pillars 3. After central parts 18 have inflated, the upper and lower sleeve parts 18b and 18c inflate and cover the entire front surfaces of the front pillars 3 from the base part to the upper end part thereof, as shown in Figures 1, 6, and 7. Consequently, the installation locations of the air bag modules 15 are not limited to the areas around the bases of the front pillars

3. Instead, the air bag modules 15 can be installed in positions that are offset from the bases of the front pillars 3 toward the center of the vehicle V and the degree of freedom of the air bag module installation layout can be increased.

[0045] The air bag 18 is stored in the module case 16 as follows: upper and lower sleeve parts 18b and 18c of are folded onto the substantially upper half of the central part 18a about the aforementioned base sides; then, the central part 18a is rolled up from its upper end so that the rolled up end is on top. As a result, the unfolding of the air bag 18 is directed upward during inflation and interferes little with the front windshield 2. Thus, the unfolding performance is not hampered by interference of the air bag 18 with the front windshield 2 and the front pillar 3.

[0046] Incidentally, if the central part 18a were rolled up from its upper end so that the rolled up end is on the bottom, the unfolding of the air bag 18 would be directed downward during inflation and there would be the possibility that the airbag would readily interfere with the front windshield 2 and the front pillar 3. Therefore, one can understand the advantageousness of the unfolding performance provided by configuration of the air bag 18 in this embodiment.

[0047] Furthermore, since upper and lower sleeve parts 18b and 18c are folded on top of the central part 18a, sleeve parts 18b and 18c do not interfere with the front windshield 2 or the front pillar 3 the central part 18a when upper and lower sleeve parts 18b and 18c inflate and unfold after the central part 18a has inflated and unfolded. Therefore, the unfolding performance of the air bag 18 can be improved.

[0048] Thus, the entire front surfaces of the front pillars 3 can be covered when the air bags 18 inflate and unfold. As a result of the long, narrow unfolding behavior of the air bags 18 along the front pillars 3 in the vertical directions, it is possible for the air bags 18 to shift sideways in the transverse direction of the vehicle V as shown in Figure 7. More specifically, when substantially rectangular the central part 18a first inflates and unfolds at a slant toward the front pillars 3 as in this embodiment, the degree of shifting toward the outside in the transverse direction of the vehicle tends to become large. When this occurs, the lower lateral part of the air bag 18 that faces the outside in the transverse direction contacts the stay 12 of the hood pop-up device 11 and the stay 12 can function as the stopper 20 to prevent the air bag 18 from shifting sideways.

[0049] More specifically, the lower part of the air bag 18, i.e., the lower sleeve part 18c, is sized so that it wraps around the stay 12 when the air bag inflates and unfolds, as shown in Figures 7 and 8. Since this arrangement increases the degree to which the air bag wedges into the stay 12, the invention is highly effective at preventing the sideways shifting of the air bag 18. The air bag 18 can be made to inflate and unfold properly such that it does not shift sideways in the traverse direction of the vehicle with respect to the front surface of the front pillar 3 and the unfolding stability of the air bag 18 can be increased.

[0050] Also, this embodiment is advantageous from the standpoints of both design and cost because uses the stays 12 of the hood pop-up devices 11 effectively as the stoppers 20 for preventing the sideways shifting of the air bags 18.

SECOND EMBODIMENT

[0051] Referring now to Figure 11, a vehicle air bag system in accordance with a second embodiment will now be explained. In view of the similarity between the first and second embodiments, the parts of the second embodiment that are identical to the parts of the first embodiment will be given the same reference numerals as the parts of the first embodiment. Moreover, the descriptions of the parts of the second embodiment that are identical to the parts of the first embodiment may be omitted for the sake of brevity. In this embodiment, a vertically oriented projection 24 having undulations on an arc-shaped circumferential surface is provided on a rear edge of the stay 12 that serves as the stopper 20 in the first embodiment.

[0052] Therefore, this feature of the second embodiment adds to the effects of the first embodiment. Since the lower lateral part (sleeve part 18c) of the base fabric wedges into the arc-shaped, undulated circumferential surface of the projection 24 when the air bag 18 inflates and unfolds, the air bag 18 does not slip with respect to the stay 12 and the sideways shifting prevention effect with respect to the air bag 18 can be increased.

THIRD EMBODIMENT

[0053] Referring now to Figure 12 to 14, a vehicle air bag system in accordance with a third embodiment will now be explained. In view of the similarity between the first and third embodiments, the parts of the third embodiment that are identical to the parts of the first embodiment will be given the same reference numerals as the parts of the first embodiment. Moreover, the descriptions of the parts of the third embodiment that are identical to the parts of the first embodiment may be omitted for the sake of brevity. In this embodiment, a cylindrical cover 25 covers the stay 12 that serves as the stopper 20 in the first embodiment.

[0054] The cover 25 has a bellows form that is made of an elastic material, such as plastic or rubber, with sufficient rigidity to retain its shape. The cover 25 is flexible so that it can follow the behavior of the stay 12 as shown in Figures 13 (A) and (B). The cover 25 has a recessed part 26 formed in substantially the center of its rearwardly facing lateral surface so as to extend in the vertical direction.

[0055] Thus, the third embodiment adds to the effects of the first embodiment. Harm to the air bag 18 can be

prevented because cylindrical the cover 25 prevents direct contact between the stay 12 and the base fabric of the air bag 18 as shown in Figure 12.

[0056] Also, since the base fabric of the air bag 18 aligns with the recessed shape of the rear surface of cylindrical the cover 25 and wedges into recessed part 26 as shown in Figure 14, the air bag 18 does not slip with respect to cylindrical the cover 25 and the sideways shifting prevention effect can be increased.

[0057] Each of the aforementioned embodiments uses the stays 12 of the hood pop-up device 11 as the stopper 20 for preventing sideways shifting of the air bag 18 and places one each in positions to the outside of air bag modules 15 (left and right sides) in the transverse direction of the vehicle V. However, it is also acceptable to install a plurality of separate stoppers 20 in addition to the stays 12 so that the air bag 18 is even more reliably prevented from shifting sideways.

[0058] The air bag 18 can also be housed inside the module case 16 by folding the lower sleeve part 18c onto substantially the upper half of the substantially rectangular central part 18a such that it is on the bottom of substantially the lower half of the central part 18a and rolling up the central part 18a from its upper end so that the rolled-up end is on top as previously described. In the late stage of the inflation and unfolding of the air bag 18, the lower sleeve part 18c unfolds downward and kicks the stay 12 (i.e., the stopper 20). As a result, the air bag 18 is deterred from shifting sideways toward the outside in the transverse direction of the vehicle V and the sideways shifting prevention effect can be increased.

FOURTH EMBODIMENT

[0059] Referring now to Figure 15, a vehicle air bag system in accordance with a fourth embodiment will now be explained. In view of the similarity between the first and fourth embodiments, the parts of the fourth embodiment that are identical to the parts of the first embodiment will be given the same reference numerals as the parts of the first embodiment. Moreover, the descriptions of the parts of the fourth embodiment that are identical to the parts of the first embodiment may be omitted for the sake of brevity. In this embodiment, the upper guide 22 that prevents the air bag 18 from arching up in the first embodiment comprises a connecting member 27 arranged so as to span between the upper surface of the module case 16 to the vicinity of the circular folded edging part 21a on the rear end edge of the engine hood 1.

[0060] The connecting member 27 is made of an elastic material, such as plastic, with sufficient rigidity to retain its required shape. The rear end part of the connecting member is provided with downward-projecting protruding part 28, which is stepped shape in the longitudinal direction of the vehicle V. It is flexible and capable of elastic deformation such that it can follow the behavior of the rear end part of the engine hood 1.

[0061] Thus, in the fourth embodiment, as the air bag 18 inflates and unfolds, the upper surface of the air bag base fabric aligns with the shape of protruding part 28 on the rear end part of the connecting member 27 as shown in Figure 15 (A) to (C) and the upper surface of the base fabric takes on an undulated shape. The flow of gas along the upper surface of the inside of the air bag is directed downward at one point (as indicated by the arrows in the same figure) due to the undulated shape and the mainstream of the gas flow is made to flow substantially in alignment with the slant of the front windshield 2 and the front pillar 3. As a result, similar effects to those of the first embodiment can be achieved.

[0062] Also, the protruding part 28 and the longitudinally stepped shape of the connecting member 27 make is possible to tune the direction of the gas flow along the upper surface of the inside of the air bag 18 and to guide the upward unfolding behavior of the air bag 18 in a continuous manner from the upper surface of the module case 16 to the rear end edge of the engine hood 1. Thus, the controllability of the unfolding behavior can be improved.

[0063] Furthermore, the elasticity of the connecting member 27 can absorb variations in the upward behavior of the air bag 18 and even further improve the controllability of the unfolding behavior of the air bag 18.

FIFTH EMBODIMENT

[0064] Referring now to Figure 16, a vehicle air bag system in accordance with a fifth embodiment will now be explained. In view of the similarity between the fourth and fifth embodiments, the parts of the fifth embodiment that are identical to the parts of the fourth embodiment will be given the same reference numerals as the parts of the fourth embodiment. Moreover, the descriptions of the parts of the fifth embodiment that are identical to the parts of the fourth embodiment may be omitted for the sake of brevity.

[0065] In this embodiment, a bottom guide member 29 that guides the unfolding of the bottom surface of the air bag 18 when the air bag inflates and unfolds is provided from the upper surface of the cowl top 4 to the bottom part of the front windshield 2. The bottom guide member 29 is made of plastic or a metal plate. Its bottom end is fixed to the cowl top 4 with a fastening member 30 and its upper end is forms a sloped surface that is disposed with a space between itself and the front windshield 2.

[0066] For convenience, this embodiment uses the connecting member 27 presented in the fourth embodiment as the upper guide 22 for preventing the air bag from arching up, but the invention is not limited to such a guide device.

[0067] Thus, the structure of the fifth embodiment adds to the effects of the first through fourth embodiments. When the air bag 18 expands from under the rear

end part of the engine hood 1 in the initial stage of inflation and unfolding, the bottom surface of the air bag 18 is guided by the bottom guide member 29 and contact with the front windshield is avoided completely. As a result, the unfolding performance of the air bag 18 is improved even further.

[0068] The terms of degree such as "substantially", "about" and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed.

[0069] This application claims priority to Japanese Patent Application No. 2000-227816. The entire disclosure of Japanese Patent Application No. 2000-227816 is hereby incorporated herein by reference.

[0070] While only selected embodiments have been chosen to illustrate the present invention, it will be apparent to those skilled in the art from this disclosure that various changes and modifications can be made herein without departing from the scope of the invention as defined in the appended claims. Furthermore, the foregoing description of the embodiments according to the present invention are provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents. Thus, the scope of the invention is not limited to the disclosed embodiments.

Claims

1. A vehicle air bag system comprising:

   a collision detection device (10) that produces a detection signal upon detection of a collision between a front of a vehicle (V) and an obstacle;
   a hood pop-up device (11) that is arranged under a rear end part of a front hood (1) to move up said rear end part of said hood (1) when actuated based on said detection signal from said collision detection device (10); and
   an air bag module (15) that is arranged in a cowl top (4) under said rear end part of said hood (1), said air bag module (15) having an air bag (18) that is inflated to expand out toward a front windshield (2) from between said cowl top (4) and said rear end part of said hood (1) when said hood pop-up device (11) is actuated, said air bag (18) being configured to cover a region ranging from a base part to an upper end part of a front surface of a front pillar (3).

2. A vehicle air bag system as recited in claim 1, wherein

   said rear end part of said hood (1) is provided with a deformation prevention member (21) that is configured to prevent said rear end part from being deformed by said inflation of said air bag (18).

3. A vehicle air bag system as recited in claim 2, wherein

   said deformation prevention member (21) comprises a circular folded edging part (21a) formed by expanding said rear end edge of an outer hood panel (1a) of said hood (1) downward in a curved shape.

4. A vehicle air bag system as recited in any one of claims 1 to 3, wherein

   said rear end part of said hood (1) has an upper guide (22) that is configured to prevent said air bag (18) from arching up when said air bag (18) expands on a lower side of said rear end part of said hood (1).

5. A vehicle air bag system as recited in claim 4, wherein

   said upper guide (22) includes a circular folded edging part (21a), a protruding part and a recessed part, said circular folded edging part (21a) having a curved shape extending downwardly from said rear end edge of said hood (1), said protruding part (22a) being formed at said front side of said circular folded edging part (21a) so as to expand downward in a curved shape, and said recessed part (22b) being formed between said circular folded edging part (21a) and said protruding part (22a).

6. A vehicle air bag system as recited in claim 4, wherein

   said upper guide (22) is arranged to span between an upper surface of a module case (16) and said rear end part of said hood (1), and to undergo elastic deformation such that it expands and contracts freely, said upper guide (22) having a connecting member (27) that has a downwardly projecting protruding part (28) with a stepped shape in a longitudinal direction of said vehicle (V).

7. A vehicle air bag system as recited in any one of claims 1 to 6, wherein

   said rear end part of said hood (1) has a lateral guide (23) on its lower side that is configured to prevent said air bag (18) from shifting sideways toward a lateral side of said vehicle (V) when said air bag (18) expands.

8. A vehicle air bag system as recited in claim 7, wherein

   said lateral guide (23) comprises a circular folded edging part (23a) extending downwardly in a curved shape from on a lateral edge of said rear end of an outer hood panel (1a) of said hood (1), and a protruding part (23b) extending downwardly in a curved shape from a lateral part of a rear end part of an inner hood panel (1b).

9. A vehicle air bag system as recited in any one of claims 1 to 8, further comprising

a stopper (20) disposed laterally outside of said air bag module (15) with respect to a transverse direction of said vehicle (V) to prevent said air bag (18) from shifting sideways when said air bag (18) inflates in a vertical direction of a front surface of said front pillar (3).

10. A vehicle air bag system as recited in claim 9, wherein

said stopper (20) comprises a stay (12) of said hood pop-up device (11) that extends upward when said rear end part of said hood (1) is sprung up.

11. A vehicle air bag system as recited in claim 10, wherein

said stay (12) of said hood pop-up device (11) has a vertically oriented projection (24) with undulations on an arc-shaped circumferential surface on a rear edge of said stay (12).

12. A vehicle air bag system as recited in claim 10, wherein

said stay (12) of said hood pop-up device (11) is covered with a cylindrical cover (25) having a flexible elastic member.

13. A vehicle air bag system as recited in claim 12, wherein

said cover (25) has a recessed part (26) extending in a vertical direction which is formed at substantially a center portion of a rear lateral surface of said cover (25).

14. A vehicle air bag system as recited in any one of claims 1 to 8, wherein

said air bag (18) includes

a substantially rectangular central part (18a) that inflates and unfolds long and at a slant from a module case (16) toward said front pillar (3), and upper and lower sleeve parts (18b, 18c) extending from said central part (18a) in a continuous manner, each of said upper and lower sleeve parts (18b, 18c) having a substantially triangular shape with a base side forming a lateral side an upper section of said central part (18a) such that said upper and lower sleeve parts (18b, 18c) inflate to form a substantially rectangular shape that extends in said vertical direction and cover said front surface of said front pillar (3) from said base part to said upper end part.

15. A vehicle air bag system as recited in any one of claims 9 to 13, wherein

said air bag (18) includes

a substantially rectangular central part (18a) that inflates and unfolds long and at a slant from a module case (16) toward said front pillar (3), and upper and lower sleeve parts (18b, 18c) extending from on said central part (18a) in a continuous manner, each of said upper and lower sleeve parts (18b, 18c) having a substantially triangular shape with a base side forming a lateral side an upper section of said central part (18a) such that said upper and lower sleeve parts (18b, 18c) inflate to form a substantially rectangular shape that extends in said vertical direction and cover said front surface of said front pillar (3) from said base part to said upper end part, said lower sleeve part (18c) being sized to wrap around said stopper (20) when said air bag (18) inflates.

16. A vehicle air bag system as recited in claim 14 or 15, wherein

said air bag (18) is housed inside said module case (16) such that said upper and lower sleeve parts (18b, 18c) fold onto said upper half of said central part (18a) about said base sides, and said central part (18a) is folded up from its upper end so that said upper end is folded on top of an upwardly facing surface of an inner end of said central part (18a).

17. A vehicle air bag system as recited in claim 16, wherein

said upper and lower sleeve parts (18b, 18c) of said air bag (18) fold onto said upwardly facing surface of said upper half of said central part (18a).

18. A vehicle air bag system as recited in claim 15, wherein

said air bag (18) is housed inside said module case (16) by folding said upper and lower sleeve parts (18b, 18c) onto substantially said upper half of said central part (18a) such that at least said lower sleeve part (18c) is on a bottom side of said upper half of said central part (18a), and folding said central part (18a) from its upper end so that said upper end is folded on top of an upwardly facing surface of an inner end of said central part (18a).

19. A vehicle air bag system as recited in any one of claims 1 to 18, further comprising

a bottom guide (29) extending from an upper surface of said cowl top (4) to a lower part of said front windshield (2) to guide a lower surface of said air bag (18) when said air bag (18) inflates.

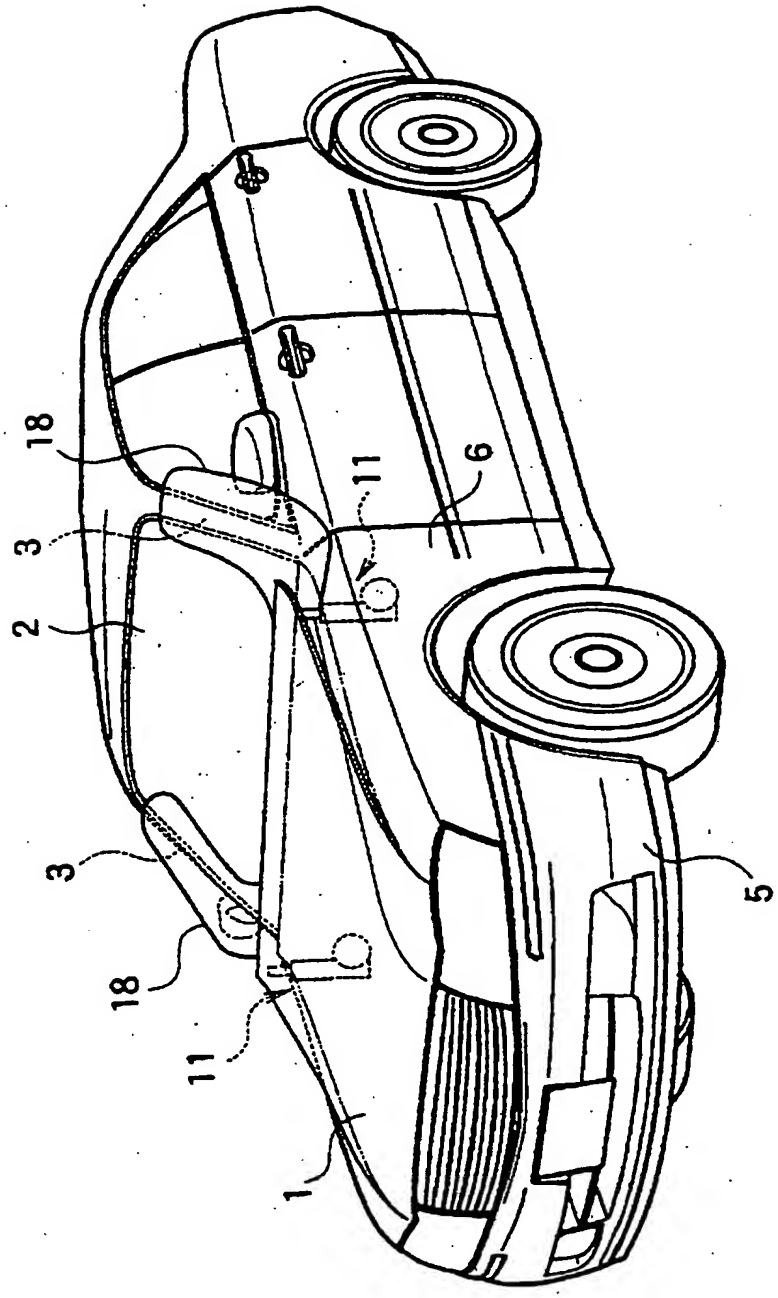

Fig. 1

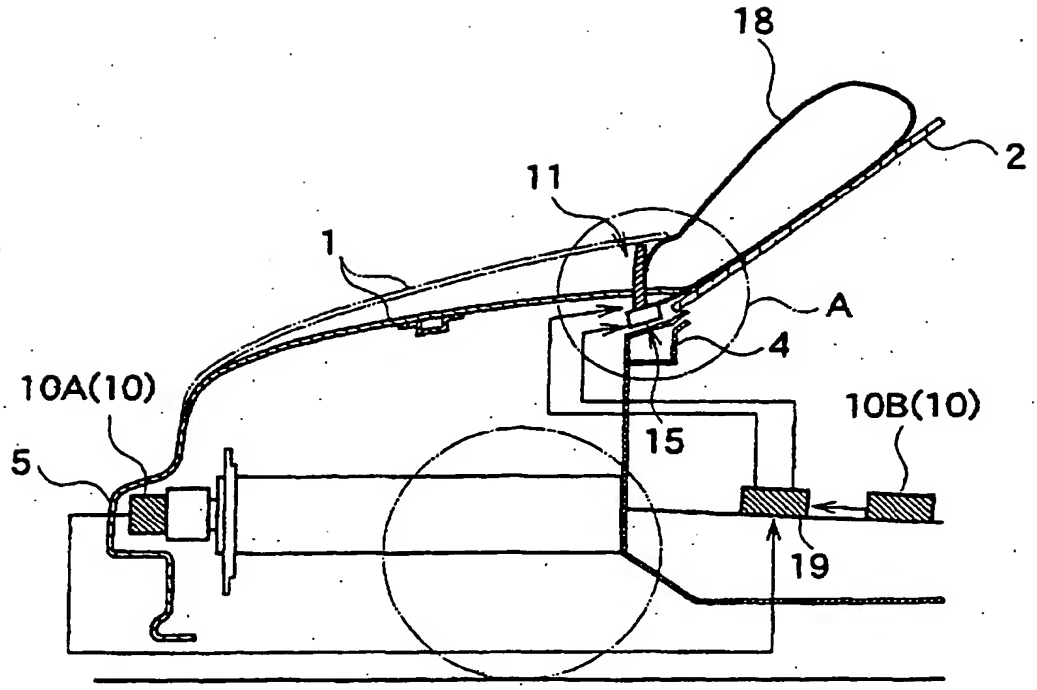

Fig. 2

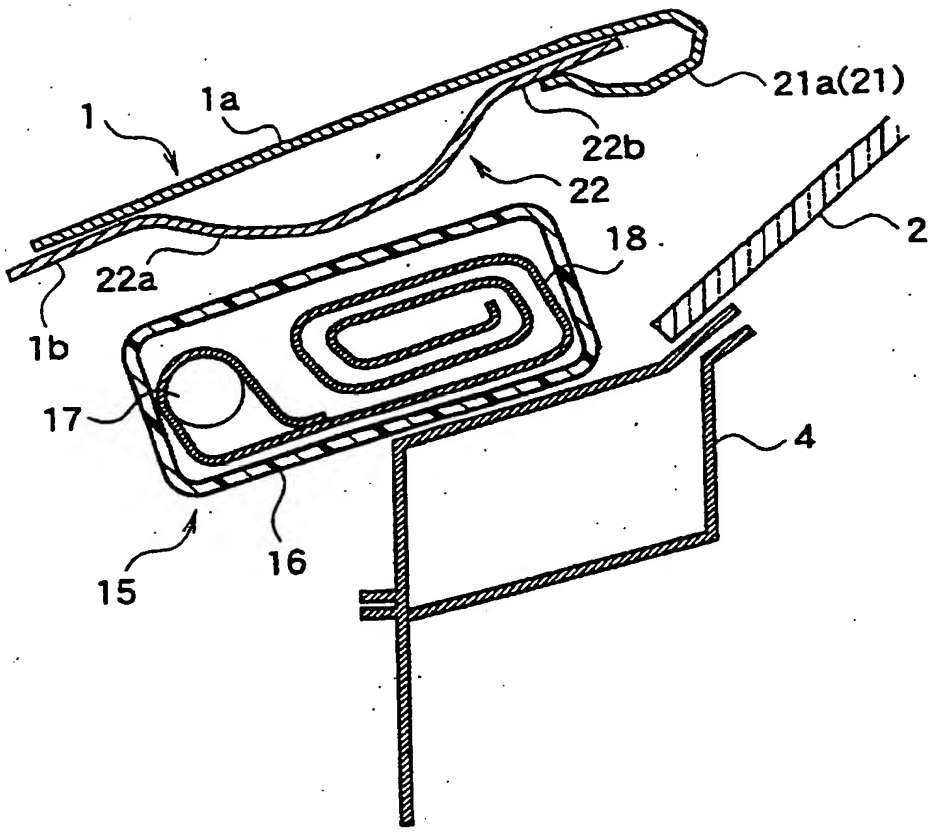

Fig. 3

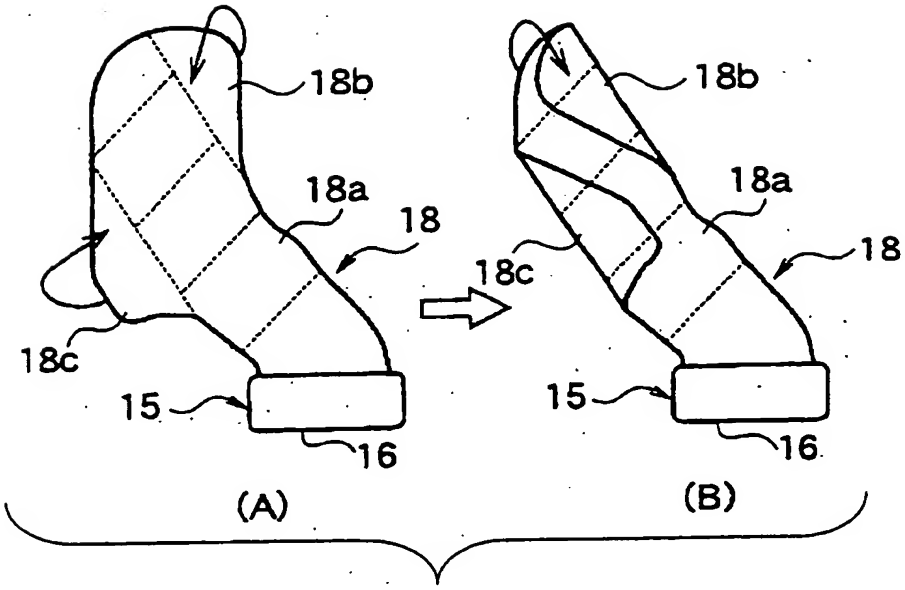

Fig. 4

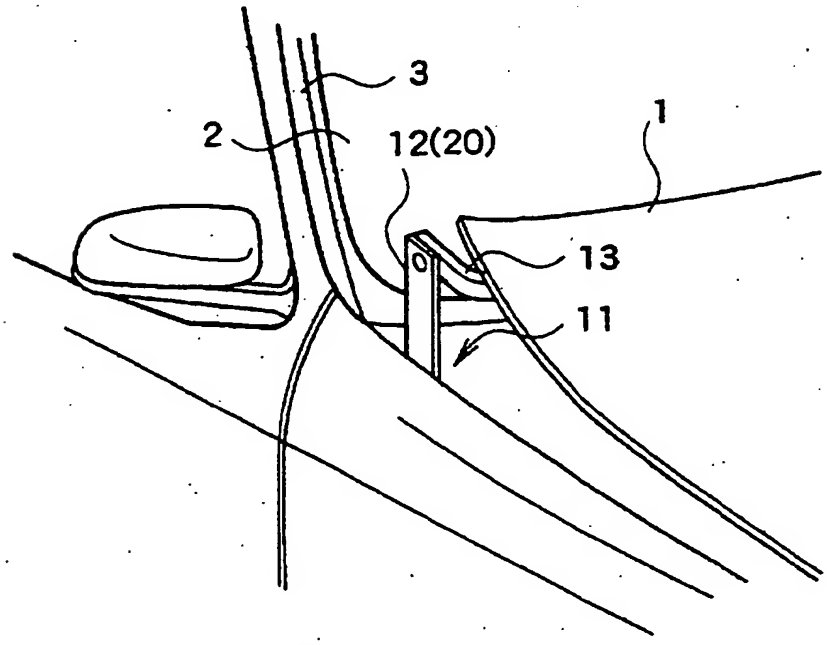

Fig. 5

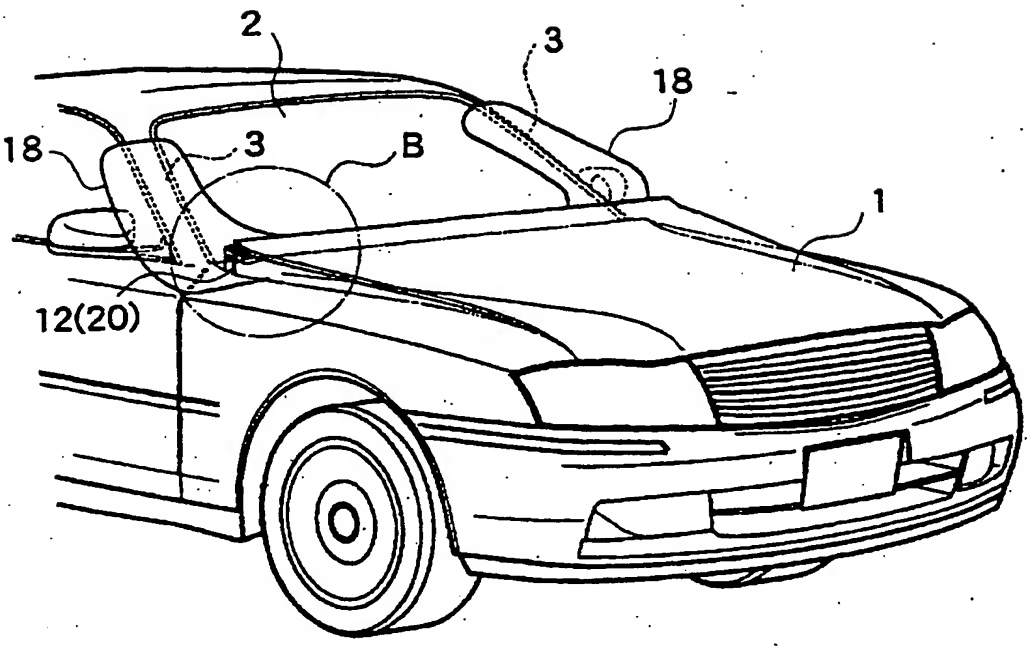

Fig. 6

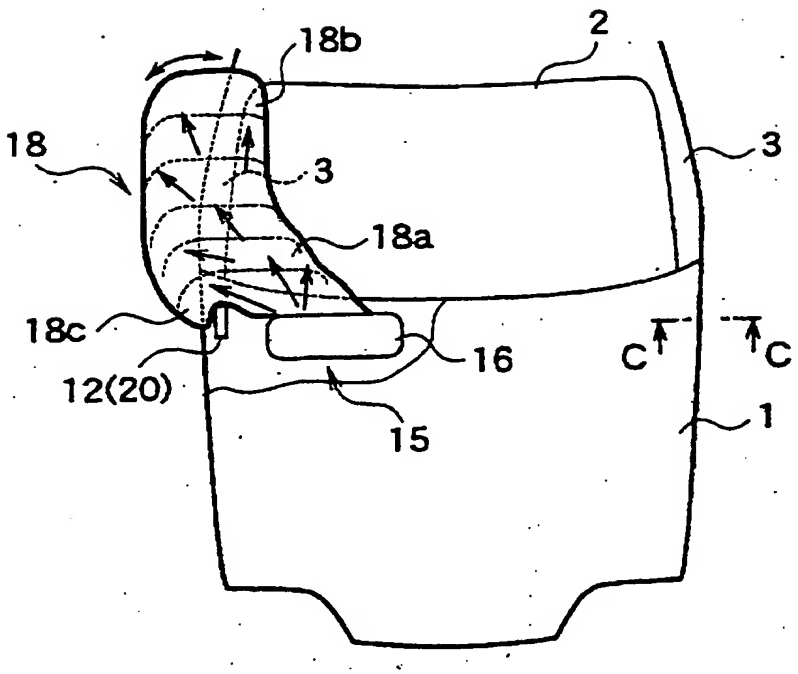

Fig. 7

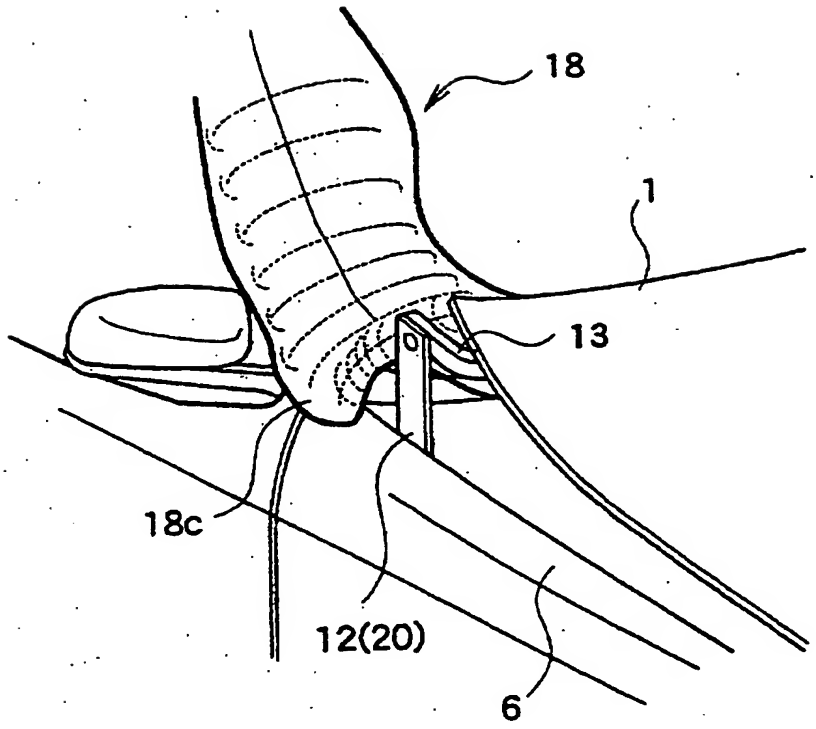

Fig. 8

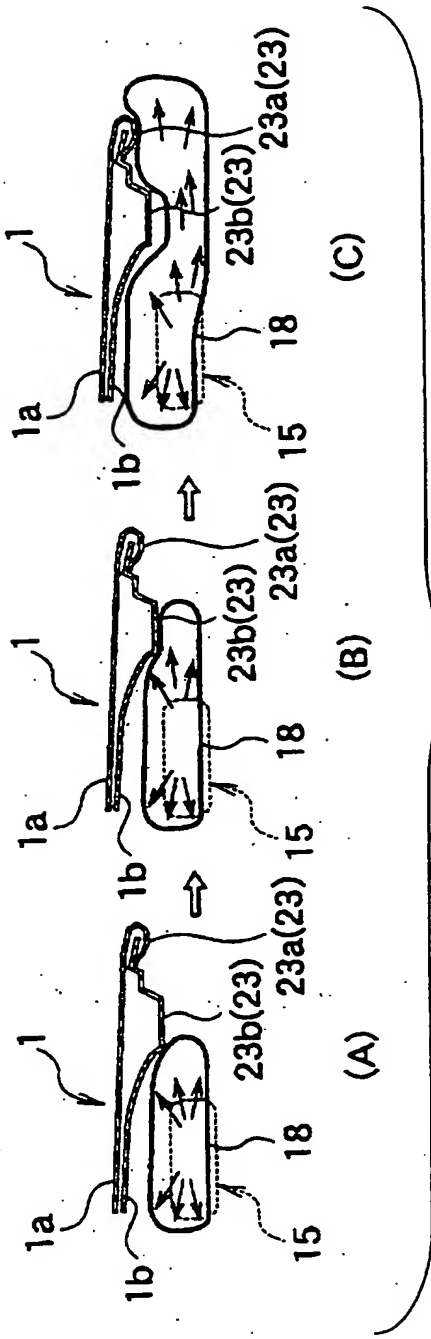

Fig. 9

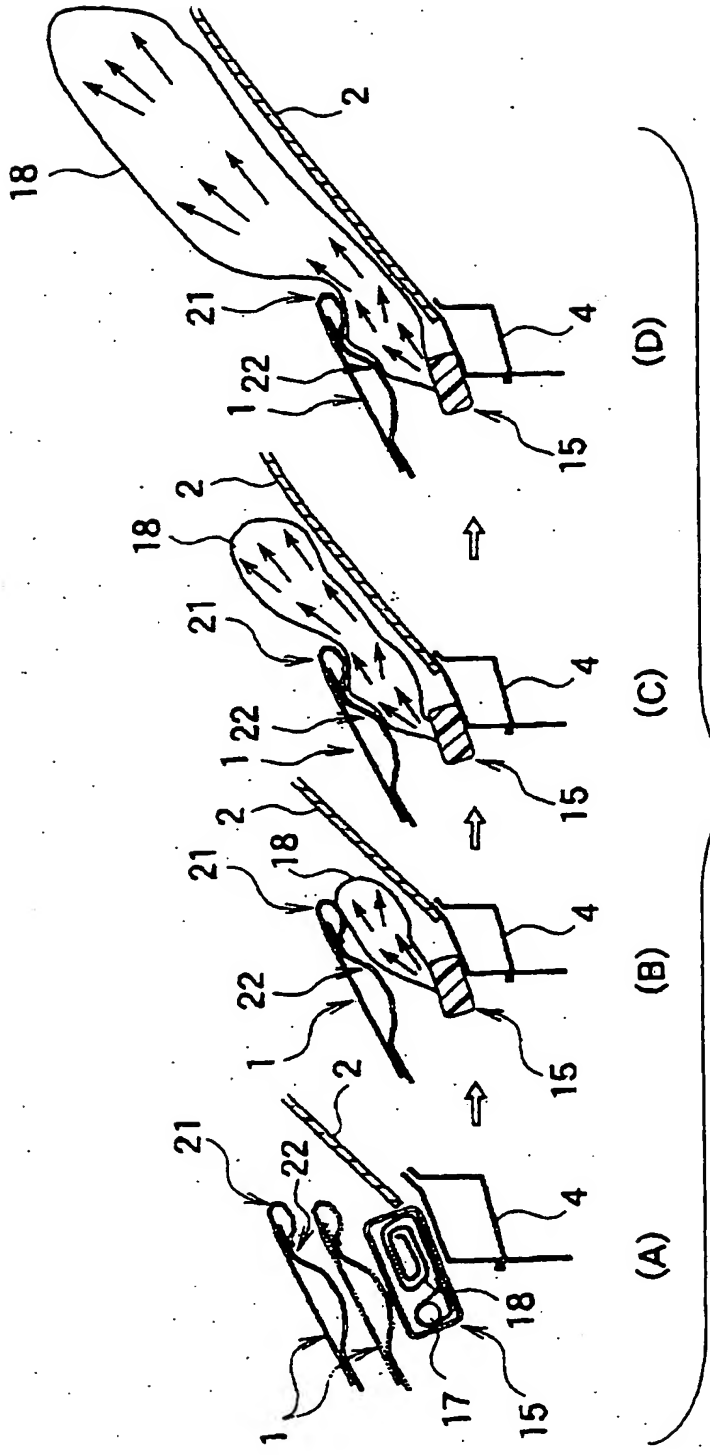

Fig. 10

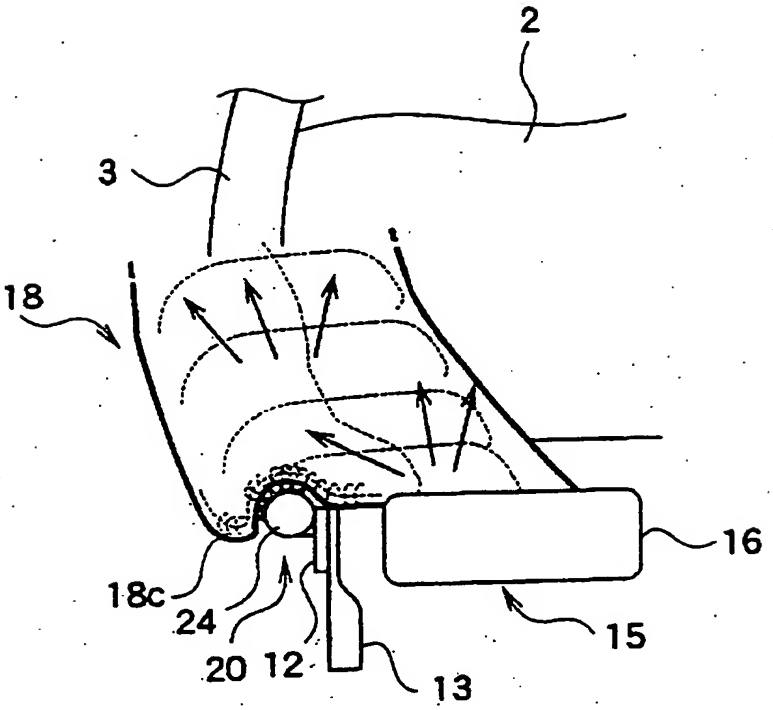

Fig. 11

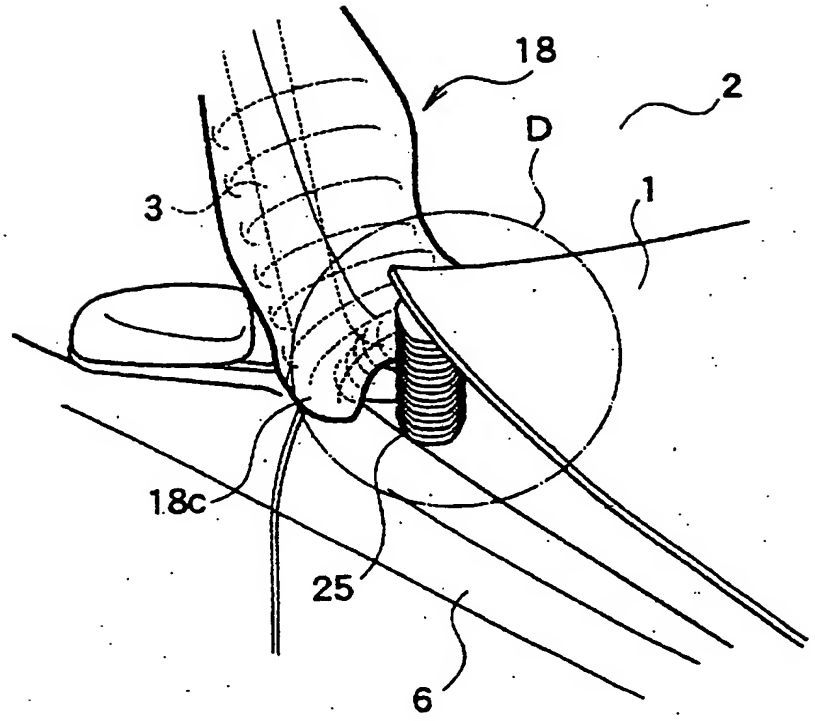

Fig. 12

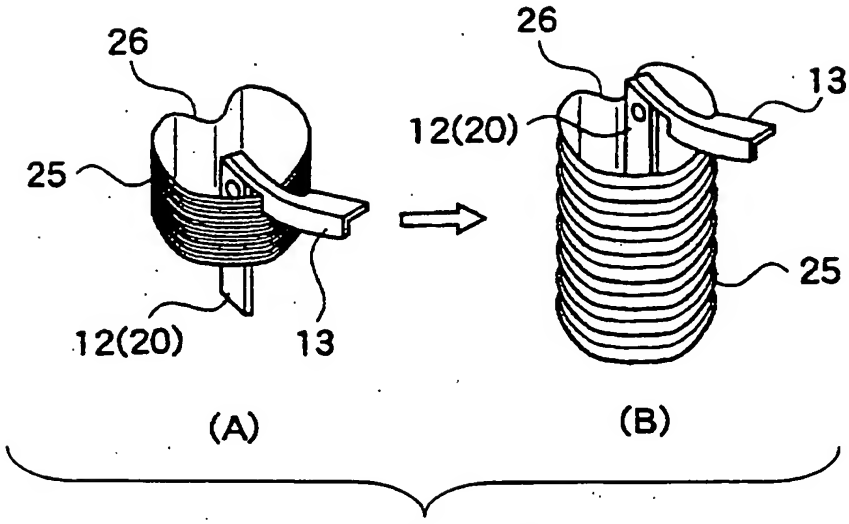

Fig. 13

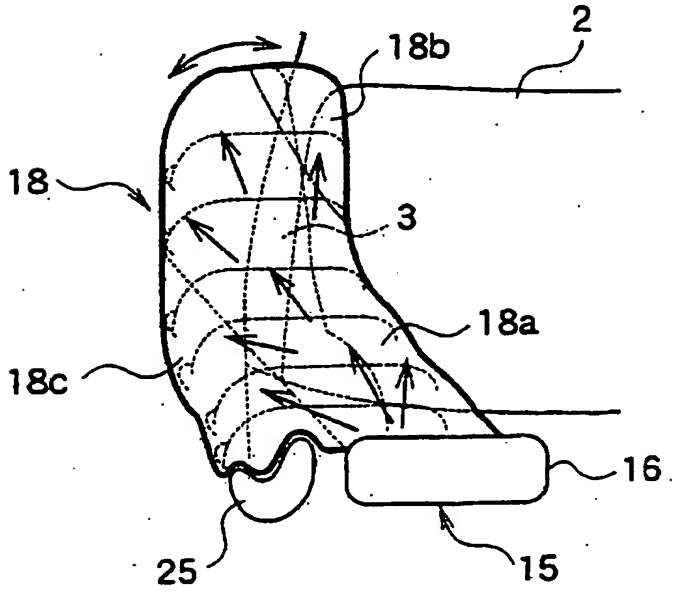

Fig. 14

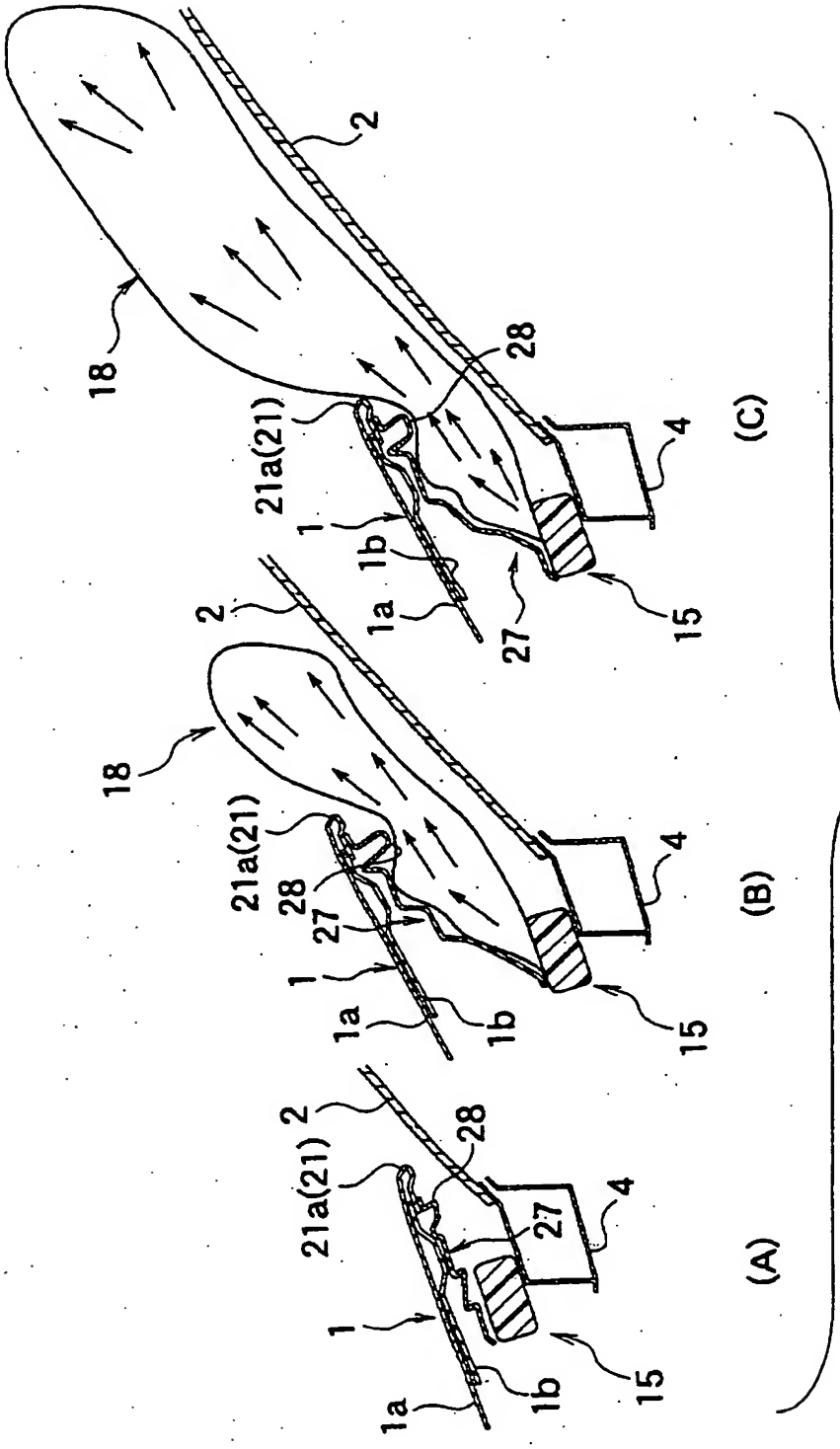

Fig. 15

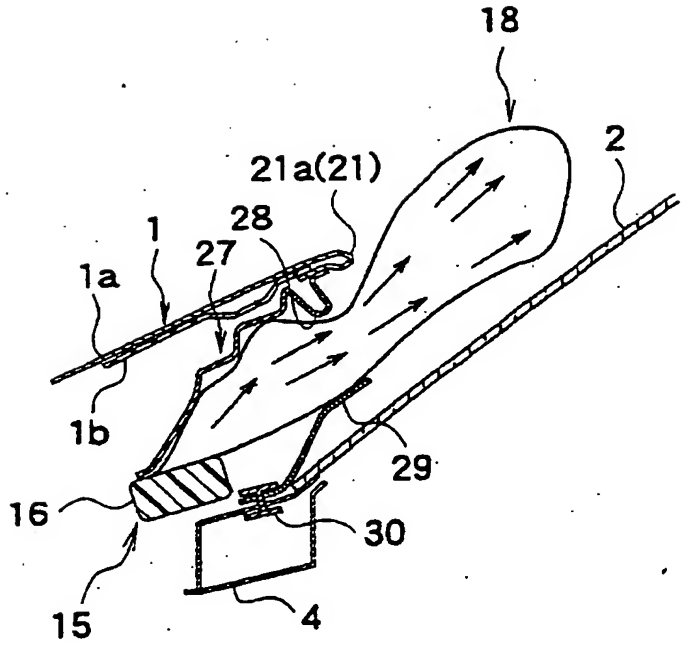

Fig. 16

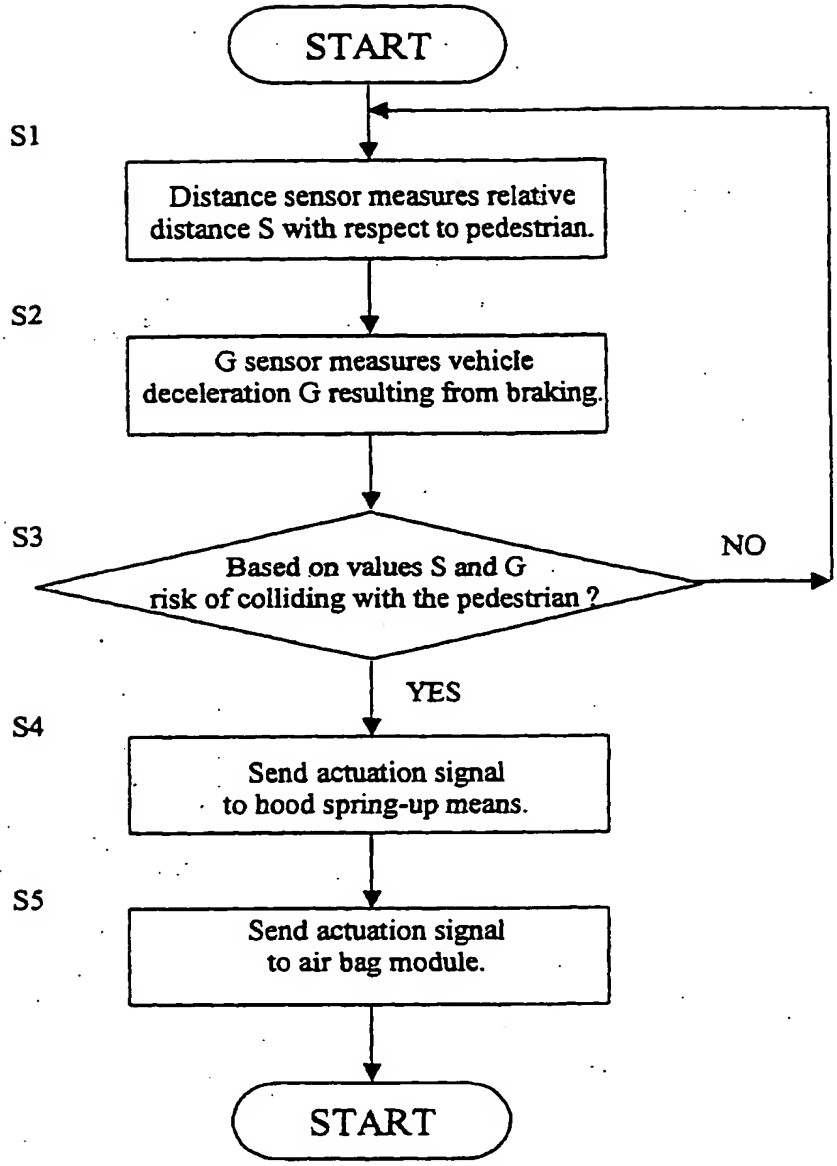
START
S1
Distance sensor measures relative distance S with respect to pedestrian.
S2
G sensor measures vehicle deceleration G resulting from braking.
S3
Based on values S and G risk of colliding with the pedestrian ?
NO
YES
S4
Send actuation signal to hood spring-up means.
S5
Send actuation signal to air bag module.
START

Fig. 17